



OCEANOGRAPHIC RESEARCH IN THE FEDERAL GOVERNMENT

FISCAL YEAR

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OCEANOGRAPHIC RESEARCH
IN THE
FEDERAL GOVERNMENT

(Supplement to ICO Pamphlet No. 3,
National Oceanographic Program,
Fiscal Year 1963)

Interagency Committee on Oceanography
of the
Federal Council for Science & Technology



ICO Pamphlet No. 5
31 May 1962

REPORT OF THE
INTERAGENCY COMMITTEE ON OCEANOGRAPHY
PANEL ON RESEARCH

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FOREWORD

The Federal Council for Science and Technology was created by the President to "consider problems and developments in the field of science and technology . . . affecting more than one Federal agency or concerning the overall advancement of the nation's science and technology" To facilitate the review and coordination of government-sponsored work in the marine sciences, the Federal Council formed the Interagency Committee on Oceanography. Since fiscal year 1960, the Interagency Committee on Oceanography has been responsible for preparing a coordinated national plan for work in oceanography. This plan has been published each year as the National Oceanographic Program.

In accomplishing its planning and coordinating functions, the Interagency Committee employs the services of panels of specialists in the various areas which make up the national program: research, surveys, ship construction, instrumentation and facilities, international cooperation, and manpower and training. In preparing the fiscal year 1963 National Oceanographic Plan, the Interagency Committee asked its Panel on Research to prepare a summary of oceanographic research accomplished by government agencies in FY 1962 or planned for FY 1963.

The Panel provides a forum in which proposed research projects are discussed and evaluated on a government-wide basis. This exchange of research information is a valuable contribution to the advancement of oceanography, and through this device each government agency may benefit from research performed by all others. The information included in Oceanographic Research in the Federal Government was compiled by the Panel from the contributions of member agencies, and by contacting nonmember agencies for descriptions of their programs. Members of the Panel responsible for this report are:

Dr. A. E. Maxwell, Chairman	Office of Naval Research
Mr. B. E. Olson	U. S. Navy Hydrographic Office
Mr. V. Brock	Bureau of Commercial Fisheries
Dr. H. B. Stewart, Jr.	U. S. Coast & Geodetic Survey
Dr. R. G. Bader	National Science Foundation
Dr. I. E. Wallen	Atomic Energy Commission
Dr. F. A. Chace, Jr.	Smithsonian Institution
Dr. D. L. Ray, Observer	National Academy of Sciences Committee on Oceanography

The ICO is also indebted to representatives of agencies who are not members of the Research Panel for information concerning the programs of their own institutions.

The Federal Council for Science and Technology believes that oceanographic research is vital to the defense of the United States, and to the welfare of its people. This report has been published to facilitate the exchange of research information among government agencies, and to provide information to private users about existing research programs in the Federal Government. It is hoped that it will be useful in assessing the quality and extent of present day research and in providing a basis for future planning.

INTRODUCTION

In ICO Report No. 3, The National Oceanographic Program for FY 1963, representing activities of eight Federal departments or agencies, is set forth in broad functional areas of research, instrumentation, ship construction, surveys, facilities and support of the International Indian Ocean Expedition. This current report contains details of the research program itself. It has been prepared primarily as a medium for exchanging information on current as well as planned research, to implement coordination between different agencies engaged either in the sponsorship or active conduct of this program, and as a compendium of on-going activity, to serve as a guide to participating scientists.

The report has been organized around six major research objectives, or fundamental questions about the sea. Within each category, projects have been grouped by sponsoring Federal agency, with budget data for FY 1962 and FY 1963. Needless to say, many research programs may simultaneously attack more than one scientific objective. In this event, the project description has been repeated, but funding has been split so that amounts listed are mutually exclusive. In those cases where an agency lends personnel or equipment in support of research, but without specific budget allocation, the funding amount is simply shown as zero. Totals, delineated by objective and by agency, are tabulated at the end of the report.

Because the missions and roles of individual agencies do not coincide identically with the various scientific objectives, more than one agency may be obliged to engage in the same type of research. The problem of describing and determining the factors governing oceanic circulation is an example. Currents govern the distribution of salinity, temperature, and other characteristics affecting underwater sound transmission - a principal concern of the Office of Naval Research. Currents are important in Bureau of Commercial Fisheries studies of the distribution of larval fish, commercial fish populations, and nutrient materials involved in marine food cycles. Information about the velocities and directions of currents is important to the Coast and Geodetic Survey for use in navigational studies. As a consequence, the Office of Naval Research, the National Science Foundation, the Bureau of Commercial Fisheries, the Navy Hydrographic Office, the Coast and Geodetic Survey, and several other agencies are all involved in research concerning ocean currents.

Through programs of mutual support by these different agencies, an understanding of the sea may be achieved far more swiftly than with only a single agency's efforts, focused on a more limited set of objectives. In fact, only by such cooperation can this program advance at a satisfactory pace, and without duplication.

Although this report deals with the National Oceanographic Program, which is largely financed with Federal funds, much of the research itself is conducted at private oceanographic institutions and universities. These have been identified wherever feasible in the report. The accomplishments of scientists at these private laboratories have in great measure contributed to the success of the United States in advancing its research program in oceanography.

OBJECTIVE ONE - TO DESCRIBE THE DISTRIBUTION OF PHYSICAL AND CHEMICAL PROPERTIES OF THE OCEANS AND TO UNDERSTAND THE DYNAMIC PROCESSES WHICH AFFECT THIS DISTRIBUTION

No portion of the oceanographic research program is so fundamental to the understanding of the ocean as is the study of its motion. Whether it be small scale turbulence or general circulation patterns, these movements determine the distribution of the physical, chemical and biological properties within the sea. In a like manner, the air-sea interactions and geological characteristics of the sea bottom are either affected by or affect the ocean circulation. It is the study of the water's characteristics and dynamics that pervades all of oceanography. Since before the time of the Challenger Expedition in 1872, which is usually acknowledged as the "beginning of oceanography", man has striven to describe the ocean movements and to determine the dynamic forces which drive them. Through field studies much has been learned about the surface circulation, its westward intensification and the meandering nature of its major currents. Similarly, theoretical and model studies have produced significant advances in the understanding of the ocean movement. Yet, less than ten years ago, a new ocean current was discovered in the Equatorial Pacific which is second only to the Kuroshio. Neither the origin nor terminus of this Equatorial Undercurrent has been fully described, nor have the dynamics been successfully determined. This one example only serves to illustrate the immensity and complexity of research tasks devoted toward achieving objective one.

DEPARTMENT OF DEFENSE

DEPARTMENT OF THE NAVY

Office of Naval Research

FY-62 \$5,234,000

FY-63 \$6,397,000

Every seagoing research ship supported by this office contributes continuously to the stockpile of descriptive information about the oceans. Soundings, bathythermographs, hydrographic stations, biological trawls and sediment cores are routine procedures on research expeditions. Data of this nature will be collected in nearly every geographic area of the world, including the Norwegian, North, Baltic, Mediterranean, Bering, Chukchi, Caribbean and South China Seas, as well as the Atlantic, Pacific, Indian, Arctic and Antarctic Oceans. Much of this work is done in areas of strategic interest to the Navy.

Within objective one, problems of general and detailed circulation of the oceans are receiving the most attention. Theoretical approaches to determine the ocean circulation are pursued actively at the Woods Hole Oceanographic Institution, New York University, Chesapeake Bay Institute, University of Stockholm and the Scripps Institution of Oceanography. Recently, a series of equations was derived that described the entire mass transport of the Atlantic Ocean. To improve these equations future work will be directed

toward several parameters such as wind stress over the water, coastal boundary conditions and the effect of bottom topography on currents. With the rapid accumulation of current observations it is becoming possible to verify and modify the theoretical work.

In order to test theoretical studies, work is being carried out with several experimental models, some of which use rotating basins. While earlier work attempted to model the real oceans, the present trend is to reach agreement between theory and experiment by using simple boundary conditions. The Woods Hole Oceanographic Institution and the University of Stockholm have strong and well-coordinated model investigations which are being accelerated. Results of theoretical and model work are proving to be extremely valuable in planning field investigations.

Gross field measurements of the large scale circulation systems will be continued in FY-63, and detailed investigations of individual current systems and of circulation in the deep ocean will receive increased attention.

The Arctic Research Laboratory of the University of Alaska has developed techniques enabling it to maintain small research stations upon pack ice. This technique permits the establishment of several floating stations throughout the Arctic Basin which should greatly add to our understanding of Arctic circulation. The newly discovered ice island, ARLIS II, will continue to be occupied as long as it remains in an area of interest. Ice island T-3, now in a favorable position, will be occupied. In the Arctic, Lamont's standard oceanographic measurements and geochemical observations are closely coordinated with those of the Arctic Research Laboratory and other groups making geophysical investigations. Also in the Antarctic, Lamont will emphasize the region proximate to the Antarctic convergence.

Much of the work will be concentrated in the equatorial regions. New York University, Texas A & M College, Johns Hopkins University, University of Miami, Woods Hole Oceanographic Institution and the Narragansett Marine Laboratory will participate in the investigation of the Equatorial Atlantic and the region off the west coast of Africa in cooperation with the efforts of the Bureau of Commercial Fisheries and Coast & Geodetic Survey. Deep current work will be carried out in the Atlantic and Pacific Oceans by scientists from the Narragansett Marine Laboratory, Woods Hole Oceanographic Institution and Scripps Institution of Oceanography using new techniques and equipment. Anchored buoys and Swallow floats will play an important role in these measurements. It is anticipated that radio telemetering will be installed on the line of buoys measuring currents between Cape Cod and Bermuda.

FY-63 will also see the first major effort to observe the Indian Ocean current structure and changes in it caused by shifting monsoon winds. Operating on Office of Naval Research funds, ships from the Scripps

Institution of Oceanography, Lamont Geological Observatory, and Woods Hole Oceanographic Institution will participate in these investigations. The Navy's support in this area constitutes a substantial portion of the U. S. part of the International Indian Ocean Expedition.

Other oceanographic institutions have extensive current programs in waters adjacent to their laboratories. For example, the Chesapeake Bay Institute has a program to trace the movement of a fluorescent dye, Rhodamine B, in Chesapeake Bay. This dye can be followed over a 10-20 day period permitting the determination of weak current patterns not readily detectable from direct current measurements. Similarly, regional programs will be continued and expanded where possible.

Numerous programs are underway within institution and industry laboratories to develop new and better equipment for the measurement of currents and other parameters associated with the physical and chemical variables in the sea. These efforts will be accelerated and the resulting improvements of techniques made available to other laboratory and agency programs.

An understanding of turbulent processes is a necessary prerequisite to the development of objective forecasting systems for any of the internal oceanic parameters. The use of Rhodamine B in tracing water particles will be further developed by the Chesapeake Bay Institute primarily to study the estuarine diffusion problems. Lamont Geological Observatory will apply this same technique to deep sea diffusion problems. At the University of Miami and New York University, surface measurements of diffusion will be expanded to include subsurface measurements.

In addition to the foregoing programs that are concerned primarily with acquiring more basic knowledge about the oceans, there are many programs in the Office of Naval Research devoted to applying this knowledge to Naval problems. These programs, which provide information for anti-submarine warfare, are also very productive in gaining a further understanding of the oceans, and they will continue in FY-63 with greater emphasis on the effects of the environment. The applied programs are concentrated at the Marine Physical Laboratory and the Applied Oceanographic Group at Scripps Institution of Oceanography, Hudson Laboratories of Columbia University and the Woods Hole Oceanographic Institution.

Hydrographic Office

FY-62 \$80,000

FY-63 \$80,000

Hydrographic Office research in physical and chemical properties of the oceans is directed toward the solution of military problems. Oceanographic data are particularly valuable for military planning and for utilization in forecasting. Emphasis will be placed on three activities: refinement of data collection, especially instrumentation; research into dynamic oceanic principles; and utilization of data for specific military applications.

Data from synoptic observations have become increasingly important in developing prediction techniques and in supplying information necessary for climatic presentations. Increased use of fixed stations - Texas towers, ocean station vessels, and shore facilities - has given rise to changing instrumentation requirements. Ocean survey and research vessels also need more sophisticated instrumentation. Design work is proceeding on a package system for these vessels. Data presentation techniques will be reviewed to produce more refined and usable environmental data. Emphasis will be directed toward presentation of data in terms of operational problems.

Bureau of Ships

FY-62 \$334,000

FY-63 \$570,000

Through programs at the Navy Electronics Laboratory and Lamont Geological Observatory, the Bureau maintains an active interest in the distribution of the physical and chemical properties of the ocean with emphasis on the effect of distribution on sonar conditions. Emphasis is placed on the spacial and temporal changes of these properties with considerable effort being directed to the Arctic region. A program of near-shore oceanography is pursued by the Mine Defense Laboratory. Again, this program has the application to military problems - mine warfare - as the primary goal.

DEPARTMENT OF THE ARMY

*Office of the Chief of Engineers

FY-62 \$30,000

FY-63 \$50,000

The provision of navigation channels into the seacoast ports requires studies of tides, salinity intrusion into bays and estuaries, and the mixing of the saline waters with the fresh water. Studies of tidal theory (including currents) as applied to coastal water and estuaries and the methods of applying these theoretical studies to field conditions will be continued as an important part of the research program.

The mixing of the saline waters with the fresh water has created problems of silting by flocculation, and research on the nature of mixing and flocculation is a continuing project in the field and laboratory. The chemical and physical properties of estuarine waters to a considerable extent determine the degree (and location) of shoaling. Work to define these properties, and the basic mechanisms of their interactions, is continuing.

Beach Erosion Board

FY-62 \$ 22,000

FY-63 \$134,000

Tidal currents at inlets and estuaries are important in beach erosion processes near inlets. Studies of the nature of these tidal currents are part of the Board's FY-1963 research project for the study of the effect of inlets on adjacent beaches.

DEPARTMENT OF COMMERCE

Coast & Geodetic Survey

FY-62 \$200,000

FY-63 \$300,000

Although some of the Coast & Geodetic Survey's work at sea is motivated by specific research problems on which the Bureau is engaged, the greatest portion is of an exploratory type aimed at (1) description of the physical and chemical characteristics of the oceans, and (2) acquisition of oceanographic research data for the Bureau and for others working in the field of oceanography. The Coast Survey is undertaking comprehensive investigations in cooperation with scientists from other agencies. In the extensive oceanographic investigations carried out in FY-1962 by the USC&GS ship PIONEER in the North Pacific, information was compiled on many phases of oceanography including bathymetry, gravity, magnetics, temperature, salinity, dissolved oxygen, plankton, currents, bottom sediments, radiochemistry, productivity, and meteorological measurements. In addition to work of the PIONEER, other USC&GS ships are adding increasing amounts of oceanographic work to their charting activities. The working season of the four major ships is being extended to permit the collection of additional oceanographic data.

The Coast Survey's world-wide network of tide stations is the only source of information on sea level variations, and these observations will continue in FY-1963.

In addition to providing needed data for research on physical and chemical properties of the ocean, the USC&GS utilizes these data to study the dynamic processes that affect the observed distributions. Recent projects include studies of the effect of bottom topography on tsunamis (seismic sea waves), and it is planned to contract for additional research on the modes of generation of these destructive waves. Research has proceeded on the effect of waves and currents of migrating underwater sand ridges and the Bureau is providing a grant to Johns Hopkins University to continue this research. Studies have related the observed temperature and sea level anomalies along the west coast to variations in atmospheric circulation. An upwelling situation along the Florida east coast has been described and explained; an anomalous rise of the land in southeast Alaska is being studied by utilization of sea level information; bottom currents have been studied at the outer edge of the continental shelf; and aerial photogrammetric techniques are being investigated as a means of understanding coastal and estuarine currents. Research of this type will continue in FY-63.

In FY-63 the development plan of the USC&GS is aimed toward providing instrumentation for use in understanding the physics of the oceans. Developmental work is planned on systems for monitoring coastal and estuarine currents, on a multisampler for rapid observations of physical and chemical factors, and improved deep-sea current measuring devices.

DEPARTMENT OF INTERIOR

Bureau of Commercial Fisheries

FY-62 \$ 850,000

FY-63 \$1,219,000

Surface currents, upwelling, temperature, salinity, oxygen and phosphate content and many other oceanographic parameters greatly influence the biological productivity of the sea. Divergent and convergent currents may create areas of enrichment and they often concentrate the food of important fishes such as herring, mackerel, salmon, sardines and tuna. Time and rate of seasonal warming of coastal and offshore waters influence distribution and migrations of fishes; for example, the northward movement of Atlantic menhaden in the spring of the year and the appearance of large skipjack tuna in the summer fishery of the Hawaiian Islands can now be predicted on the basis of time of spring warming. The peak spawning time of Pacific sardines is known to vary from one year to the next by as much as two months in response to oceanic temperature changes no greater than 1°C. Unfavorable currents in some years may carry haddock larvae away from the usual nursery areas and a large part of the young are lost. Fishery scientists believe that the pattern of ocean currents at the time of spawning is an important factor in the survival of year broods in many important fisheries.

Oceanography of the central and eastern Pacific is currently being studied from several Bureau laboratories located in Hawaii, Alaska and along the Pacific coast of the United States. Some principal contributions are: (1) monitoring the seasonal north-south drift of the California current extension from stations near Hawaii where trends in sea surface temperatures, salinity and sea levels are determined; (2) definition of physical and chemical features of Pacific subarctic waters as part of an extensive program to explain factors controlling high-seas distribution of salmon; (3) detailed analysis of North Pacific sea-surface temperature data by months from 1935 to the present along with related meteorological processes which may cause variations in water transport, heat gain or loss and sea levels; (4) cooperative studies with California agencies on the California current system and physical oceanographic features of the eastern, subtropical and tropical Pacific. Prevailing sea-surface temperatures for the North Pacific east of 180° longitude are charted and published monthly for use in fishing and research operations.

Much of the Bureau's research in the Gulf of Mexico and along the Atlantic coast is directed towards coastal and inshore oceanography to describe the environment and to determine productivity of coastal resources. Circulation and net current flow through bays and inland passages are under study as a significant contribution to research on shrimp, oysters and menhaden. Through a small contract with Woods Hole Oceanographic Institution, temperature and salinity conditions are monitored routinely at numerous Atlantic coastal stations and from lightships and Texas towers. Circulation patterns over the New England offshore banks and in the Gulf of Maine are studied by use of drift

bottles and transponding, free-floating buoys. The Bureau's laboratory in Washington, D. C., is preparing monthly Atlantic coastal and offshore sea-surface temperature charts for the period of 1953 to the present. Research presently underway will be continued by the Bureau during FY-63 and in addition new programs will be commenced which will contribute significantly to knowledge of physical and chemical properties of the oceans. A biological and physical oceanographic investigation of the tropical, equatorial Atlantic and West African coastal and offshore waters will commence in the spring of 1963. Objectives of this program are to describe the extent of fishery resources in the equatorial Atlantic, to relate distributions of fish populations to environmental conditions and to contribute knowledge on physical attributes of Atlantic waters. It is planned that this program be a cooperative effort with the Navy, Coast & Geodetic Survey, Bureau of Commercial Fisheries and several private oceanographic institutions.

Oceanographic research in the eastern tropical Pacific is to be increased to define zones of high biological productivity. Areas of nutrient enrichment through upwelling and mixing along current boundaries will be sought. Thermocline topography and changes within the mixed layer will be studied. Monthly charts of sea-surface temperatures which the Bureau is now preparing for more northerly waters will be extended to at least 10°S. latitude and offshore to 100° or 110° W. longitude, depending upon availability of data from merchant ships and fishing vessels.

Since many of the marine research programs of the Bureau require data over a series of years before results are meaningful, much of its research on physical and chemical properties of the oceans during FY-62 will be continued into 1963. A follow-up expedition into the equatorial Atlantic is planned for the latter part of calendar year 1963, and oceanographic studies in the eastern tropical Pacific will be continued.

In addition to these programs of research, it is realized that there is a need for greater amounts of biological, chemical and physical oceanographic data collected in time series over wide expanses of the oceans. Such data will provide clues to changes in the ocean climate to which fish respond. Therefore, an expansion of research is proposed which will monitor environmental conditions. Quarterly biological and oceanographic surveys are to be started in New England waters of the Atlantic.

The Bureau proposes to investigate the trade winds zone of the central Pacific to determine principles and parameters of climatic oceanography in this area which are of great interest for fisheries, weather, navigation and national defense. The objective is to be attained by determination of the seasonal rates of change of surface temperature, salinity, depths of the mixed layer and currents as they are related to the physical processes of heat exchange across the sea surface.

Geological Survey

FY-62 \$106,000

FY-63 \$123,000

Current and proposed studies of the Geological Survey are concerned with the hydrologic cycle through the marine and near-shore environments. The principal effort is in shallow ocean areas where the sea is in direct or indirect communication with fresh surface water and ground water. Included in the studies that will be pursued in FY-63 are: geological history of river estuaries and lagoon areas; movement of ground and surface water to the ocean; salt water incursion into fresh water supplies; occurrence and origin of fresh and salt water bodies in coastal areas; circulation and dispersion of dissolved and suspended solids in coastal areas; dynamics of tidal and contiguous ground waters; and the development of techniques and methods for measuring processes and obtaining data. Among other things, these studies will provide knowledge about the sources, the circulation, and the fate of radioactive, organic, and industrial waste pollutants; as well as the products of natural weathering and erosion in ground water and rivers that drain into the sea.

Determination of significant physical and chemical properties and patterns will of necessity be undertaken in connection with local and regional studies of general environments of sedimentary systems.

DEPARTMENT OF THE TREASURY

Coast Guard

FY-62 \$ 0

FY-63 \$ 0

Within the Coast Guard, the principal field of research into physical and chemical properties and the interrelated dynamic processes lies in the International Ice Patrol. The principal area of interest is the Northwest Atlantic Ocean, chiefly the Grand Banks and the Labrador Sea. These waters have been under continuing study since 1914 for the purpose of better understanding the factors which affect the origin, drift, transport and deterioration of icebergs. Toward this end, Ice Patrol research includes water mass analysis, surface and sub-surface currents, volumetric transport and heat budget studies of the area.

In FY-63, the Ice Patrol oceanographic vessel CGC EVERGREEN will occupy approximately 400 oceanographic stations during the period March-August. In addition, a network of buoys will be established across the Labrador Current to study short term fluctuations in that flow. Results of the surveys will be analyzed at the Ice Patrol Oceanographic Unit Offices located at the Woods Hole Oceanographic Institution.

In other fields of oceanographic research, Coast Guard activities are principally those of data collection in cooperation with other agencies. These include operations of ocean stations, Bering Sea Patrol, polar operations, lightships, and offshore light towers.

These programs are not funded as part of the Coast Guard research program, but through the budgets of the Ice Patrol and Ocean Station Vessels.

NATIONAL SCIENCE FOUNDATION

FY-62 \$2,150,000

FY-63 \$2,450,000

The Earth Sciences Program of the Division of Physical, Mathematical and Engineering Sciences supports a variety of research aimed at developing a better understanding of the dynamic processes associated with the physical and chemical properties of the ocean. Oceanography is supported at some 30 universities, colleges and other institutions; the investigations include the coastal and near-shore waters as well as the deeper areas of the Atlantic Ocean, Pacific Ocean, Indian Ocean, Caribbean Sea and the Gulf of Mexico.

Theoretical investigations and model studies on general circulation and exchange rates are being undertaken by scientists at New York University, Harvard University, the Johns Hopkins University and the University of Washington. Such work will advance our understanding of oceanic current development and estuarine and coastal circulation.

Major field studies aimed at elucidating the character of both deep and shallow water circulation are being undertaken by Scripps Institution of Oceanography, Woods Hole Oceanographic Institution, Oregon State University, the University of Miami, the University of Washington, Texas A&M College and Rhode Island State University.

Likewise, the chemistry of sea water is being investigated by various means. For example, mass spectrographic analyses of dissolved gases are being accomplished at Amherst University, Scripps, and the University of Washington. These efforts are concentrated on quantities such as oxygen-18, nitrogen-15, carbon dioxide, deuterium, argon, etc., for the purpose of understanding the history of sea water and the exchange processes between the sea surface and the atmosphere. Trace element chemistry of both the stable and radioactive isotopes are being investigated at Scripps, Woods Hole and Miami.

The U. S. participation in the International Indian Ocean Expedition is being supported in part by the National Science Foundation. Scripps, Woods Hole, Lamont and Rhode Island will conduct physical and chemical oceanographic programs. In addition the R/V ELTANIN will operate in Antarctic waters.

The National Science Foundation support of research vessel construction, conversion, and operation will enhance the physical and chemical investigations in the oceans as well as all other oceanographic research programs.

OBJECTIVE TWO - TO DETERMINE THE INTERRELATIONSHIPS OF THE OCEAN AND ATMOSPHERE

The mutual effects of atmosphere and ocean are so interrelated and complex that study of the oceanic environment cannot be conducted without simultaneous consideration of the atmospheric environment. Conversely, the study of marine meteorology cannot neglect oceanographic factors. Sea swell and storm surges, all products of the surface winds, continually modify the air-sea boundary. Although the exchange of matter and energy occurs at the air-sea interface, to understand fully the impact of these exchanges, studies must extend to some depth in both ocean and atmosphere. Turbulent mixing and convective processes distribute heat energy within a thick layer at the ocean's surface. The ocean, thereby, becomes a tremendous storehouse of energy. This layer at the ocean's surface is of prime concern in this research. It shows annual, seasonal and diurnal changes in thickness, heat content, and other characteristics. Similarly, the lower atmosphere over the ocean is laden with moisture and salt nuclei received from the oceans and its stability is determined in a large measure by the temperature of the water body over which it has traveled.

DEPARTMENT OF DEFENSE

Office of Naval Research

FY-62 \$1,291,000

FY-63 \$1,365,000

Measurements of surface roughness, surface water temperatures, lapse rate in the air, incoming and outgoing radiation, wind velocities and turbulence in the water and air are providing new insights into the interrelationship of the ocean and atmosphere. These investigations are being carried out intensively in the Atlantic by Woods Hole Oceanographic Institution and New York University, and by Texas Agricultural & Mechanical College in the Gulf of Mexico.

Investigators at Woods Hole Oceanographic Institution are critically examining both sides of the ocean-atmosphere interface and the exchange of energy, water vapor and chemicals. For example, they will thoroughly study the effect of bubbles on transmission of sound in the water and the introduction of salt nuclei into the air through bursting of the bubbles, a phenomenon which appears to be an important factor in producing rainfall. Acquisition of a four engine aircraft, especially modified for meteorological measurements, will greatly extend the geographical coverage of this program during FY-63.

During the International Geophysical Year, the Navy initiated research to investigate the abundance of carbon dioxide in the oceans and the atmosphere. During FY-63 this work will continue at a modest level at Woods Hole Oceanographic Institution, Scripps Institution of Oceanography, University of Stockholm, and Texas Agricultural & Mechanical College. Research is now concentrating in areas of high latitude in order to obtain a more complete global picture of the distribution of CO₂ in

the atmosphere and to determine the amount being absorbed by the sea. These studies will attempt to determine if man is significantly modifying the world's climate through the introduction of large quantities of CO₂ into the air from the burning of fossil fuels.

The extensive program on air-sea interaction at New York University will be accelerated by enlarging the staff and replacing the present ship with a larger and more efficient vessel. NYU will continue to direct their interest toward prediction capabilities by integrating computer techniques into their investigations.

In the Gulf of Mexico, Texas Agricultural & Mechanical College has a moored buoy recording ocean temperatures at intervals to 1000 feet in depth in addition to measuring several surface meteorological phenomena. These results, coupled with the towed thermistor chain in the surrounding area, will provide data on spacial and temporal exchanges far exceeding that now available. In FY-63 it is planned to expand the program of buoy, tower and ship instrumentation.

Work on energy exchanges between the water, ice and atmosphere is being conducted in the Arctic by the University of Washington. It is being carried out in close cooperation with the Arctic Research Laboratory at Point Barrow.

Fundamental research is conducted on the whole spectrum of wave energies. New York University will continue to expand its theoretical work on non-linear aspects using the La Grangian system. This work is proving to be very successful, and it is intimately related to non-linear problems of ship motion. Chesapeake Bay Institute, having explored the field of waves generated in limited fetches, will shift its emphasis to directional spectra and the problem of the skewed distribution of wave energy over the spectrum. The theoretical work will be followed by experimental verification. Scripps Institution of Oceanography has concentrated its effort in wave research on digital techniques. These have proven to be very effective for directional spectrum analysis. Use of high speed computers with new techniques to remove errors and the use of mathematical filters will continue to receive a great deal of attention from SIO.

Hydrographic Office

FY-62 \$100,000

FY-63 \$299,000

Both high density time series data in a local area of the ocean and the atmosphere, and synoptic information over broad areas of the ocean are important in the study of ocean-atmosphere relations. Investigations of the sea surface by the Hydrographic Office will be in close cooperation with the basic research program of the Office of Naval Research, but will be directed specifically to problems requiring an ability to predict oceanic characteristics.

Detailed investigations of the energy exchange processes between atmosphere and ocean have already been carried out on Texas Towers. Advanced instrumentation developed from these studies will be used on Argus Island, the research tower located off Bermuda. This station will provide the data required to establish new empirical relationships and to test theoretical relationships between the ocean and atmosphere. In FY-63 an oceanographic research ship will be instrumented to provide a deep-water research operation of the Argus Island type.

An oceanographic aircraft is now being outfitted and will be available for long-range survey. It will be capable of providing data such as sea surface temperature, bathythermographs, ocean wave records and supporting meteorological data.

A synthesized mathematical model of equations suitable for short-range sea water temperature structure forecasting have been reduced for tabular, nomogram and computer usage. Short-range forecasting technique research will be further developed and extended to longer range and seasonal outlooks.

Changes in thickness of the isothermal layer cannot always be related to meteorological and oceanographic activity at that location. Large-scale movement of surface and subsurface water appears to show direct relationship to atmospheric circulation. The problem will be approached from both the synoptic and the longer term climatological points of view. Additionally, a purely statistical approach to the problem will be conducted on an ocean-wide basis. A grid of predicted meteorological and oceanographic factors and extrapolation in time and space. Special research into this phenomenon will be conducted aboard ocean station vessels, Hydro survey ships and other ships as practicable. Radio telemetering oceanographic buoys will provide additional ocean coverage with repeated observations from fixed locations.

Research will continue toward a better understanding of surface waves and wave-induced sea floor pressure fluctuations. This effort will include directional spectrum analysis and correlation of surface and bottom pressure records, as well as work on prediction techniques. Continued importance will be placed on spectral analysis of many physical parameters. Empirical and semi-empirical wave models will be studied which will include examination of varied wind conditions (velocities, durations and fetches).

Within arctic regions the physical processes covering the behavior of the environment become increasingly complex. Here three distinct layers - atmosphere, cryosphere and hydrosphere - interact. Frictional forces at the air-ice and ice-water interfaces are the primary influences in producing ice movements. A major study effort will be directed at

the relationship of wind velocity and direction to ice drift velocity as well as the development of open water areas, ridges and other pressure-distribution caused deformations. Ice reconnaissance from aircraft and by satellites will provide valuable relief data. Bottom roughness data will come from under-ice submarines operating fathometers and other devices. Arctic ice drift stations will assist in development of specialized stress equipment.

Bureau of Ships

FY-62 \$400,000

FY-63 \$715,000

Because the Navy's increased submarine operations in the Arctic Ocean require a detailed knowledge of the ice conditions, the Bureau will continue to increase its efforts to understand the fundamental physics of ice formation and break up. Both laboratory and field work in ice physics will be undertaken by the Navy Electronics Laboratory. Field work will concentrate on energy exchange processes and will be carried out on temporary ice stations occupied from light aircraft. The Office of Naval Research, Hydrographic Office, and Bureau of Ships programs in the Arctic represent an integrated attack on this large and difficult-to-study area.

Studies at the Navy Electronics Laboratory's offshore tower will be accelerated to gain further insight into the hydrodynamics of surface waves and their relation to internal waves. At the University of Miami investigation will continue into the high frequency spectrum of surface waves and the ambient noise in the ocean caused therefrom. In addition, the Navy Radiological Defense Laboratory will investigate the role of waves in the distribution of radioactivity.

DEPARTMENT OF THE ARMY

Office of the Chief of Engineers

FY-62 \$100,000

FY-63 \$150,000

Wave generation by winds, the decay and modification of these waves as they travel to the shore, and the mechanics of breaking waves are part of the Corps' research program. These waves are the major destructive forces on jetties and seawalls built for navigation improvement or for protection of the shore from hurricane attack.

Beach Erosion Board

FY-62 \$79,000

FY-63 \$81,000

Measurements of ocean waves to determine the statistical wave climate in selected coastal areas is part of the Board's research program. The improvement of wave generation theory will be pursued as part of this program because waves are the most important factor in shore erosion processes. This will involve descriptions of the wave spectrum and wave variability and measurement of wave properties (as velocities, form, pressures, particle motion, etc.). At present, the Board has thirteen automatic recording stations in coastal waters and plans to

add at least four new stations in FY-63. Some of these stations are operated entirely with Beach Erosion Board funds and some on a cooperative basis with other public or private agencies. Work will be continued on the development of an economical wave-direction indicator to be installed as a component of the wave-recording stations. Some of these newer stations will utilize Coast Guard light towers as installation platforms.

Research will be continued on the construction of wave refraction and diffraction diagrams and on the reforming of waves after breaking over submerged bars.

DEPARTMENT OF COMMERCE

Weather Bureau

FY-62 \$123,000

FY-63 \$173,000

The Weather Bureau's primary interest falls within the realm of determining the interrelationship of the ocean and atmosphere. The interplay between the atmosphere and the ocean is so intimate that they can be considered as one medium separated by a discontinuity in density and velocity. The exchange of heat, moisture, momentum, gases (such as carbon dioxide and oxygen), and certain chemical elements (such as sodium, chlorine, potassium, calcium and magnesium) has profound influence on the subsequent behavior of the atmosphere and ocean. In supplying the atmosphere, the oceans serve as a warehouse of nearly infinite capacity for heat, moisture, and other properties. In turn, the faster moving atmosphere supplies the oceans, particularly the top layers, with much of their momentum. Various salts and elements released by the ocean to the atmosphere serve as important condensation nuclei which are necessary for cloud formation and ensuing precipitation. Studies of these important properties, which are necessary to a better understanding of the characteristics of both the oceans and the atmosphere, will be continued in FY-63.

Long period changes in atmospheric circulation and in weather patterns may be sensitive to the exchanges of heat and moisture between the ocean and the atmosphere. For example, an unusual pattern of wind and weather may alter the circulation of a large area of an ocean, bringing warmer temperatures to one part and colder temperatures to another. This new sea-surface temperature pattern, in turn, influences the overlying air, thus possibly prolonging the unusual atmospheric circulation pattern. Oceans are sluggish and once a pattern is established, it tends to persist, thereby introducing a long range effect on the overlying atmosphere in the subsequent weather patterns. The Bureau will continue to study the "feedback" mechanism whereby unusual weather conditions produce unusual sea conditions, particularly temperature changes, and the manner in which these, in turn subsequently introduce atmospheric changes, such as variations in paths and intensities of storms.

An important practical aspect of the Bureau's meteorological oceanography program will be concerned with "storm surges" or "storm tides" produced by hurricanes and other severe wind storms, and which cause most of the loss of life and property. Studies of these effects will involve, not only an extensive investigation of the records of abnormal tides and long-period changes in sea level supplied by the Coast & Geodetic Survey, but also basic investigations of the effects of wind force and atmospheric pressure on the height of the sea.

Coastal weather is subject to both continental and oceanic influences, and is notoriously variable. The problem assumes new importance with millions of recreational boats plying coastal waters, and the use of nuclear-powered vessels and the associated contamination problems that may arise. Particular emphasis will be placed on harbor and estuarine forecasting.

Coast & Geodetic Survey

FY-62 \$ 0

FY-63 \$ 0

This agency contributes to this research objective primarily by collecting and processing the data used for the research of others. The Coast Survey, for example, works closely with the Weather Bureau in providing tidal data for storm surge studies and with the Bureau of Commercial Fisheries in providing sea level data for use in studies during 1962 of the effect of atmospheric pressure on sea level. Similarly, the physical oceanographic observations of the Coast Survey (currents, temperature, and salinity) are used in studies of the air-sea interaction. Meteorologists from the Weather Bureau carried out a significant program from the PIONEER in FY-62. This program effort is being doubled in FY-63 although it will be budgeted under the survey program.

Maritime Administration

FY-62 \$50,000

FY-63 \$50,000

The interest of the Maritime Administration is largely in the inter-relationship of the ocean and atmosphere. In conjunction with other agencies, factors influencing weather, iceberg movements, and wave formation will be studied with increasing emphasis. Wave spectra will be recorded on ocean vessels, buoys, Texas towers, and shallow water stations. Concurrent programs in model basins equipped with wave-makers will attempt to reproduce irregular seas into which ship models can be run at various headings. The ultimate objective is to find means of calculating ship motions from model tests with greater accuracy than is possible today.

DEPARTMENT OF INTERIOR

Bureau of Commercial Fisheries

FY-62 \$25,000

FY-63 \$36,000

The Bureau of Commercial Fisheries studies processes which may affect the distribution of surface properties in the Pacific. An "Atlas of the Oceanographic Climate of the Hawaiian Islands Region", prepared

by the Bureau's Biological Laboratory in Honolulu is being readied for publication. This contains discussions on heat exchange across the sea surface, and considers the ocean-atmosphere feedback system in an area where trade winds are a major driving force in ocean circulation. Wind induced advection is being examined at the Bureau's Stanford, California laboratory in an effort to deduce a sea-surface temperature forecasting system.

The Bureau will not make a major contribution to an understanding of ocean-atmosphere interrelationships as part of future programs. The oceanographic investigation in the Central North Pacific, described under Objective One, will, however, examine heat exchange processes as part of the total study on the marine climate of the trade wind zone.

Geological Survey

FY-62 \$10,000

FY-63 \$34,000

Research by the Water Resources Division of the Geological Survey contributes to understanding the interrelationship between the sea and atmosphere through studies of the exchange of chemical substances in the hydrologic cycle; the physics and chemistry of atmospheric and surface waters near land-sea margins; and the atmospheric transfer of ions and solid particles. These investigations, which are a part of a program to study the complete hydrologic cycle, will be expanded wherever possible. In addition, during FY-63, an analysis and interpretation of waters collected on three cruises of the International Indian Ocean Expedition will be undertaken.

DEPARTMENT OF THE TREASURY

Coast Guard

FY-62 \$ 0

FY-63 \$ 0

Coast Guard activities will include marine meteorological and ocean wave observations from six ocean stations and approximately three off-shore light towers. In addition, studies of the International Ice Patrol will include the effects of short term meteorological factors on surface currents, ice transport and ice deterioration. These activities are budgeted under non research programs of the Coast Guard.

NATIONAL SCIENCE FOUNDATION

FY-62 \$ 750,000

FY-63 \$1,200,000

Air-sea interaction studies are being supported by the Atmospheric Sciences Program, Earth Sciences Program and the Office of Antarctic Programs of the National Science Foundation. These investigations, combined with those conducted or supported by other agencies will greatly enhance the knowledge in this area so vital to our understanding of climatic shifts, wave generation, the carbon dioxide budget, and the transfer of heat, water vapor and momentum. In addition it should improve our prediction capabilities with respect to sea state.

A major item of the air-sea relationship supported by the Foundation will be done in conjunction with the International Indian Ocean Expedition, primarily by scientists from the University of Hawaii, the University of Michigan and the Woods Hole Oceanographic Institution. Antarctic research will be conducted aboard the R/V ELTANIN and from the shore stations. Investigations in the North Pacific Ocean and North Atlantic Ocean are underway at Scripps Institution of Oceanography, the University of California at Berkeley, the University of Washington and Oregon State University.

OBJECTIVE THREE - TO DETERMINE THE DISTRIBUTION, KIND AND ADAPTATION OF THE LIVING POPULATIONS OF THE SEA AND TO UNDERSTAND THE INTER-RELATIONSHIPS OF THE MARINE ORGANISMS TO THE PHYSICAL AND CHEMICAL PROPERTIES OF THE SEA

DEPARTMENT OF DEFENSE

DEPARTMENT OF THE NAVY

Office of Naval Research

FY-62 \$1,232,000

FY-63 \$1,803,000

Marine biological interference with the propagation of acoustic signals underwater represents a serious problem to the Navy. This problem encompasses the recognition of false targets represented by whales, large fish, etc., and the reverberation and attenuation of energies resulting from the presence of concentrations of biological particulates in the water. Active sound production by marine animals is a corollary problem since many biological sounds closely resemble operational noises and seismic disturbances. Analyses of biological sounds will continue to be made to determine their purpose and their acoustic characteristics so that they can be predicted or recognized. Also, accurate emulation of biological sounds underwater will be investigated and may result in improved transmission systems for specialized uses.

Investigations will be made of hydrodynamic characteristics and the propulsion of marine animals. These may give insight into mechanisms to control turbulence and to manipulate boundary layers. Additional knowledge of these mechanisms would be useful in hull design for surface ships, submarines and underwater ordnance. Of interest also are the orientation capabilities of marine animals which allow them to identify targets, select them and navigate to them.

Much additional information will be sought on the control of marine deterioration and fouling of ship bottoms, cables, moored and bottom mines, underwater sound equipment and hydrofoils. Since the biological organisms responsible for deterioration and fouling often affect the configurations of carefully planned shapes and coatings adversely, causing them to lose their streamlining or anechoic properties, studies will continue of life cycles of the animals and their reaction to chemical substrata under various environmental conditions. An expansion in scope in FY-63 will emphasize investigations of deep ocean conditions since so little is known about the environment of abyssal waters and the range of adaptability of marine organisms.

Another area of interest will include investigations of biochemical and biophysical properties of individual organisms and populations, since such properties may affect the bottom sediments, the surrounding water or the surface. Some organisms are capable of modifying bottom sediments by affecting their hardness, compactness and motility. Also of interest are the products these organisms put into the water as a result of normal

metabolic activities which modify viscosity; temperature, and other physical characteristics of the water.

Considerable effort will continue to be directed to the problem of marine biological particulates which may interfere with submarine and anti-submarine warfare. Marine organisms have been shown to be extraordinarily sensitive to changes in the ambient chemistry or physical conditions of their environment. As more is learned about these phenomena, there will be corresponding increases in the level of effort. Programs of research on poisonous and venomous fishes, on the biology of sharks and shark repellents and on biologically active substances from marine organisms have been underway for several years and will be accelerated during FY-63. Of concern, is the chemical identification and pharmacological action of these substances, some of which are extremely potent and very different structurally from related substances commonly used in drugs and medicines.

Hydrographic Office

FY-62 \$ 0

FY-63 \$ 0

While the marine biology program of ONR is directed toward an understanding of the behavior, the physical and chemical characteristics and the reaction to the environment of marine organisms, the Hydrographic Office is directing its biological endeavors toward the solution of operational problems. For example, fouling of ships and underwater equipment; damage to wood and other materials by shipworms and other borers; bioluminescence, which can disclose the location of ships and submarines at night; scattering and attenuation of underwater sound by plankton and nekton; and active interference with sonar operations by sonic animals are problems that will be attacked.

Using test panels and racks, the effects of fouling organisms and marine borers on wood and underwater equipment will be studied. The test equipment arrays will be located in shallow-water coastal areas and at selected sites in deep ocean areas. Relationships between abundance and distribution of plankton organisms and the intensity of fouling will be studied.

Bioluminescent phenomena are of increasing importance to the Navy. Intensity of overall bioluminescence will be measured by photocells. Direct enumeration of bioluminescent organisms will be accomplished by using counters. Plankton from net collections and organisms filtered from water samples will be analyzed.

Primary productivity for various ocean areas will be estimated and attempts will be made to develop direct methods of predicting marine biological phenomena of importance to the Navy.

Sounds produced by marine animals will be recorded and analyzed, and the causative animals will be identified. This work will supplement previous work and will speed the eventual collection of a reference library of sounds produced by all sonic marine animals.

Scattering and attenuation of underwater sound by marine life will be studied by two methods. An attempt will be made to correlate scattering and attenuation measurements with an analysis of the plankton collected in the area. A second study will be based on collection of plankton and nekton from within the deep scattering layer as located by echo sounders and from concurrent photographs and television observations.

This research program in biology at the Hydrographic Office is funded entirely with non-research funds.

Bureau of Ships

FY-62 \$166,000

FY-63 \$198,000

The Bureau will expand the Navy Electronics Laboratory's program of identification and classification of noises originating from marine organisms. The expanded program will include analysis of ambient noise recordings from San Clemente Island and Cape Prince of Wales to determine seasonal and other characteristics. In addition, the research program of the bathyscaph TRIESTE, also carried out by scientists at NEL, will include studies of the population of the sea and the correlation of the population with the physical and chemical properties of the sea at various depths.

DEPARTMENT OF THE ARMY

Office of the Chief of Engineers

FY-62 \$ 0

FY-63 \$10,000

Information on marine borers which infest waters of the United States will be analyzed in order to determine the expected useful life of wood and concrete structures in coastal waters. This analysis will also serve to indicate the economic justification of various methods of protecting against these borers. Biological studies of borers are not planned; rather the project is an analysis of the findings of others for application to the needs of the Corps.

Beach Erosion Board

FY-62 \$ 3,000

FY-63 \$10,000

The interests of the Board in this research objective are similar to that of the Office of the Chief of Engineers, as described in the preceding paragraph. These studies, which concern marine borer activity, will be pursued jointly by the Office of the Chief of Engineers and the Board.

DEPARTMENT OF COMMERCE

The Weather Bureau and the Coast & Geodetic Survey do not budget funds specifically for research on the living populations of the sea. However, the Coast Survey contributes indirectly in two ways. First, it encourages other agencies and private institutions to place biological oceanographers aboard its ships, and it does on request collect

biological samples at sea for specific research problems. FY-1962, for example, saw biologists from the Bureau of Commercial Fisheries using plankton nets and mid-water trawls from the PIONEER to collect samples for research projects on which they are engaged, and the University of Hawaii had personnel aboard carrying out phytoplankton productivity investigations. Secondly, the Coast Survey, through its oceanographic survey operations, provides environmental data used by the biological oceanographer in determining the interrelationships between marine organisms and their environment.

DEPARTMENT OF THE INTERIOR

Bureau of Commercial Fisheries

FY-62 \$5,598,000

FY-63 \$6,136,000

Present research, although primarily ecological studies of marine communities, is oriented towards important commercial species. For these, the Bureau of Commercial Fisheries seeks an understanding of their interrelations with the physical and biological environment and studies life histories, rates of growth, recruitment, mortality, productive potential and behavior patterns which are important for efficient harvesting. Statistical research on catch and fishing effort is conducted to define abundance levels. This, in turn, allows examination of principles which govern abundance fluctuations.

In the north Pacific particular attention will be given to several species of salmon where their distribution and high seas migrations are being studied in relation to changing oceanographic conditions. Explorations for new resources, such as shrimps, crabs and bottom fishes will continue to be carried out along with ecological studies which have been undertaken on crabs and herring.

Migrations, behavior, food habits, life history and development will continue to be investigated for the yellow fin, skipjack and albacore tunas. Unexploited stocks of large tuna have been discovered in subsurface layers of the central equatorial Pacific. Forecasts of seasonal abundance of Hawaiian skipjack as shown by their response to shifts in the California current extension have been remarkably successful.

Pacific sardines, which once supported a very large fishery, have been the subject of cooperative biological-oceanographic investigations for several years. This program has shown that survival of young from spawning is highly variable from year to year, and that changing oceanographic conditions cause substantial changes in the centers of sardine abundance. Studies will continue to be conducted on behavior, physiology and genetic composition of stocks.

Studies in the Gulf of Mexico will continue to be concerned with oysters, shrimp, menhaden and other coastal fishes which are used for reduction

or for pet food. Large unfished stocks of sardine-like fishes have been discovered through exploratory surveys.

In the Atlantic Ocean, the major fishery resources are harvested from coastal waters or from offshore banks. The principal invertebrates and marine fishes requiring continued studies are oysters, clams, scallops, crabs, menhaden, flounder, herring, haddock, red fish and whiting.

Research on living populations is to be augmented in three principal areas: the equatorial Atlantic eastward to the coast of Africa; the Gulf of Mexico; and on the offshore New England banks.

The principal goals of the proposed equatorial Atlantic and West African biological investigation are definition of the geographic extent of fishery resources and research which will reveal the productive potential of these relatively poorly known waters. While there have been a number of oceanographic expeditions in the equatorial area of the Atlantic, there have not been systematic cruises across the equatorial belt from South America to Africa which have sampled biological populations and related them to current systems which may control their location and productivity. The first effort will be exploratory to show what additional work beyond an initial cruise will be needed to understand fully the physical and biological characteristics of the equatorial Atlantic.

A new research ship, the ALBATROSS IV, will be placed in service in New England waters in October 1962. New investigations into seasonal abundance, distribution and behavior of groundfish species will be undertaken. Principal areas of investigation will be the Gulf of Maine and Georges Bank.

While there is a need to increase knowledge about economically important species, the greatest progress in fishery research probably will be made through basic research not necessarily related to a particular species. Some lesser known marine animals are adaptable to experimental conditions and may be used to uncover principles which can be explored with respect to important food species that are more difficult to hold in the laboratory.

In FY-63, the Bureau's program on living populations will fall into two categories: continuation of substantial marine research effort now underway; and the launching of a new basic research effort to increase knowledge on biology of marine organisms. The principal new studies will be on:

- (a) Disease and parasite infections;
- (b) Determination of factors which control survival of critical young stages;
- (c) Taxonomic relationships.

Attention will also be given to improvements in techniques and instrumentation to increase the rate of present research and make possible new undertakings which cannot be accomplished with existing methods.

<u>Bureau of Sport Fisheries and Wildlife</u>	FY-62	\$100,000
	FY-63	\$147,000

Continuing studies will be undertaken of migratory marine fishes which are of interest to recreational fishermen. Through support received in 1960, a center of game fish research was established at Sandy Hook, New Jersey. Major activities in this center are:

- 1) conducting a National Survey of catches and an inventory of fishing facilities;
- 2) establishing a compendium of all available information on game fishes and fishing and research in progress;
- 3) developing facilities for basic research in both experimental and environmental fields;
- 4) investigation into game fish problems through contact with appropriate persons and agencies around the country;
- 5) drawing up a program for research and services to be established during the period 1961-1965.

Research will be accomplished through fellowships, grants and contracts to state conservation organizations and universities, in addition to the Bureau's own undertakings.

A program of coastal environmental research is planned for the Pacific Coast in the area between Cape Flattery and Point Conception and from Long Island to Southern Florida in the Atlantic. The role of estuaries in the lives of game fishes is to be studied. Collections of larvae and young fishes will be made in a number of estuaries. Basic life history information for game fish species will be sought.

Provision is being made for physiological studies and research on methods of rearing marine game fishes in order to learn their physical and biological requirements for early survival and growth. This research will commence in FY-62 and will continue in 1963. A deactivated Naval Base at Tiburon, California has been obtained for future West Coast operations.

Geological Survey

FY-62 \$74,000

FY-63 \$80,000

Research on a number of marine biological and biochemical problems involving the geologic history of ocean basins; the origins of marine sedimentary rocks, ores, and fuels; and isotopic and other chemical processes of present-day relevance is now being carried out in various Geological Survey laboratories. A significant expansion of such work is planned for FY-63. Typical subjects of this research include: the analysis of modern planktonic skeletal materials; the role of organisms in the origin of carbonate sediments and petroleum; the recently-discovered fractionation of hydrogen isotopes by marine bacteria; paleontological investigations of past land and ocean-current configurations; the use of marine fossils for determination of ancient climatic conditions and the dating of marine sediments; shoal-water ecology and paleoecology as applied to stratigraphic interpretation; and the investigation and possible development of a fuel cell basically powered by marine bacterial oxidation. Results of such work will apply over a very broad range of problems relating to earth history, animal physiology, mineral exploration, climatology and energy sources.

DEPARTMENT OF HEALTH, EDUCATION & WELFARE

Office of Education

FY-62 \$59,000

FY-63 \$59,000

The Office of Education awards a number of graduate fellowships for new and expanded programs in oceanography that contribute to this objective as well as objective one.

DEPARTMENT OF THE TREASURY

Coast Guard

FY-62 \$ 0

FY-63 \$ 0

Under Objective Three, the Coast Guard has no direct research activities other than the collection of data in cooperation with other research agencies. This includes plankton hauls and sampling from ocean station vessels, lightships, and the Bering sea patrol. This will continue in 1963.

NATIONAL SCIENCE FOUNDATION

FY-62 \$2,600,000

FY-63 \$3,100,000

The Division of Biological and Medical Sciences supports a wide variety of studies that show promise of leading to a greater understanding of life and living processes in the marine and estuarine environments. Much of this work is done at marine laboratories either on a continuing or a seasonal basis, and much more is carried on in other laboratories in which marine organisms are being used as experimental materials in

a variety of research problems ranging from physiology to pharmacology, and from genetics and behavioral studies to biogeography. In FY-62 and 63, individual research projects that aim to contribute to the knowledge of marine organisms will be supported in essentially all (some 20) non-governmental marine laboratories in the country where such work is conducted, and in some 70 additional universities, colleges, and other research institutions. Such work will include, for example, systematic studies on the classification, relationships, variation and evolution of marine invertebrates, fishes, algae, plankton and parasitic forms; studies on the distribution, migration, life histories and growth of such forms; their physiology, reproduction, climatic adaptations, locomotion, tolerances, behavior and functions. Work will be supported, also, dealing with the productivity of the sea, the nitrogen cycle, the effects of chemical constituents on the biota, and shallow water and deep sea communities. Support is also provided for ship time for biological oceanography and for the expansion and improvement of marine laboratories and their graduate training programs.

During FY-63, major ship facilities will be significantly advanced, with a biological research vessel being built for Duke University on the East Coast, and two made ready on the West Coast, one for Hopkins Marine Laboratory of Stanford University that is to have unique training features as a floating classroom and laboratory combined, and another at Scripps Institution of Oceanography. Other types of facilities that will be supported or that are now becoming operational include a new laboratory building at Friday Harbor Laboratories of the University of Washington; a controlled-environment facility, called a marinostat, at Hopkins Marine Station, Pacific Grove; a new laboratory building to house biological and chemical research at Woods Hole Oceanographic Institution; and a laboratory at Lamont Geological Observatory. Facility-type support is also being given to the construction of a boat basin for marine research in Texas, building expansion at the Bermuda Biological Station, the marine biological laboratory at the University of California, Santa Barbara, and the Cape Haze Marine Laboratory, and the establishment and support of the Vermillion Sea Field Station.

The biological portion of the United States participation in the International Indian Ocean Expedition will be entirely supported by NSF through Woods Hole Oceanographic Institution. Logistic support has been given by NSF to the development of the biological research program, and the USS WILLIAMSBURG is now being taken over from the Navy and undergoing reactivation in order to serve as the U. S. biological research vessel in that activity during FY-63 to 65. Some 250 American biologists responded to the invitation to submit plans for participation in this expedition, and it is foreseen that sufficient data will be gathered in Indian Ocean waters to require continuing logistic support for its assimilation for several years beyond the official termination of I.I.O.E.

Marine biological studies in Antarctic waters will also comprise an important part of the research activity of the USNS ELTANIN and shore stations in the Antarctic.

SMITHSONIAN INSTITUTION

FY-62 \$ 0

FY-63 \$250,000

An obvious need in any oceanographic program is for adequate description of the animals and plants of the sea, any one of which may become the basis for an intensive study now or at some future date. The study of ecology of these organisms naturally comes after the precise identification and description of species are available. The development of ecological biology, the foundation of all national appraisal and control of our living resources, depends to a great degree on the rapid, accurate and specific identification of organisms encountered. Accurate identification of species of organisms is a basic requirement for the elucidation of marine biological phenomena and for an understanding of the complexion of the resources of the sea.

In order to provide basic identifications of marine organisms to other scientists engaged in this national effort, and to prepare revisions and monographs of biological groups about which little is yet known, the Museum of Natural History staff will be increased from its present 21 to 70 over a ten-year period. FY-63 will see the initial effort of this expansion. Until an adequate staff is achieved, some of the early work must be carried out by contract to other institutions.

OBJECTIVE FOUR - TO DESCRIBE THE SEA FLOOR AND TO UNDERSTAND ITS LONG-TERM AND SHORT-TERM EVOLUTION; INCLUDING THE TOPOGRAPHY, GEOPHYSICAL NATURE AND SUBSURFACE STRUCTURE WITH PARTICULAR INTEREST IN THE SEA FLOOR'S RELATION TO THE SURROUNDING LAND MASSES

Some of the most marked advances in understanding the ocean basins have come about through geological and geophysical investigations of the sea floor. Less than fifteen years ago, little was known about the ocean bottom and its structure. There were few reliable soundings, no seismic refraction results, and very little magnetic or gravity data. Geothermal measurements were unknown. Within the past decade precision depth recorders and seismic refraction techniques have evolved, gravity meters have been developed that can operate on surface ships, highly sensitive magnetometers have been towed routinely by research ships and geothermal measurements have been carried out over large areas of the ocean. A large part of the significant advances in this field can be attributed to the massive effort that has been undertaken, but, in addition, some of the success can be traced to the fact that once a marine geophysical technique has been developed, it has almost invariably proved simpler and quicker to collect data at sea rather than on the continents.

Results of geological and geophysical research at sea during the past decade may be divided into three categories. The first is the identification and charting of the massive features that characterize the ocean bottom - the trenches, mountain ranges and sea mounts. Even today these features are known only in the most gross detail. Secondly, the nature and composition of the vast blanket of sediments have been investigated and described - again only in a cursory manner. Third, and more recently, the structure of the crust beneath the sediments has been examined, and attempts are being made to determine the orogenic processes that are continually modifying it. Results from all three of these categories are providing the fundamental knowledge required to understand basic problems such as the origin of the earth and other planets.

DEPARTMENT OF DEFENSE

DEPARTMENT OF THE NAVY

Office of Naval Research

FY-62 \$6,160,000

FY-63 \$7,380,000

The geological and geophysical research program of the Office of Naval Research has, for the most part, been directed at a fundamental comprehension of the sea floor, its substructure and history.

One of the prime objectives in the program is to describe the sea floor, delineating the major features such as trenches, ridges and sea mounts and to understand their origin. This effort is carried out by all sea-going vessels supported by ONR. Precision depth recorders will be

placed aboard all ships not now having this capability. New techniques of scanning the sea bottom to increase the effectiveness of research ships will be pursued jointly with other groups within the Navy. In addition, research into new and better navigation techniques will continue in order that positioning does not become a limiting factor in these investigations. Coring and dredging will be done in close harmony with the bathymetric program to provide information on the nature of sedimentation and its physical and chemical properties and to understand the processes taking place that continually modify the sediments. Most of the sedimentation studies will be carried out by oceanographic laboratories such as Lamont Geological Observatory, Woods Hole Oceanographic Institution, University of Miami, Texas A & M, Scripps Institution of Oceanography and Cambridge University, England. Every oceanic area will receive attention in this program, with major emphasis in the areas of good navigational control. These studies will be conducted in to the shore line in many places to develop an understanding of the relation of the sea bottom to the continents. For example, the continental borderland off Southern California and the South China Sea will be investigated by the University of Southern California. Similarly, coastal geography studies will be made along the East and Gulf Coast of the United States. Applied programs concerning the acoustical properties of the sediments and the reflectivity and reverberation of the topography will be accelerated in FY-63. The Hudson Laboratories of Columbia University, the Marine Physical Laboratory of Scripps Institution and the Woods Hole Oceanographic Institution will undertake the bulk of the applied research.

Other geophysical investigations of the sea floor and its substructure will be made in cooperation with the aforementioned studies. While underway, the research ships will continually measure gravity and the magnetic properties of the bottom. These results will be correlated with topography. On station, the ships will make seismic reflection and refraction measurements and will measure heat flow when possible. None of these measurements by itself can provide definitive knowledge of the earth's substructure, but the combination of all provides the only effective manner in which the crustal properties can be studied. In the past, the major features such as the mid-Atlantic Ridge and the East Pacific Rise have received the primary attention of the geophysical investigations. Studies of these areas, in particular the geophysically anomalous area of the East Pacific Rise, will continue during FY-63. Additionally, the topographic features of the Indian and Antarctic Oceans will be examined to determine what relation, if any, they have with the predominant features of the Atlantic and Pacific Oceans. As most of this work requires the use of two ships, both national and international cooperation will be fostered. In the Atlantic, the Woods Hole group will continue to work with the group at Cambridge. Lamont will cooperate with the South American countries - Argentina, Chile and Peru - and will also participate in the Indian Ocean Expedition. Texas A & M will be encouraged to expand its geophysical work. Scripps

will have three large ships capable of doing geophysical investigations in any oceanic area with the exception of the Arctic. The South Pacific and Indian Oceans will be the areas of concentration by the Scripps Institution. The Universities of Wisconsin and Michigan will cooperate with the Lamont Geological Observatory and the Arctic Research Laboratory in the geophysical investigation of the Arctic basin. Ice islands and sea floor stations will be utilized. It is hoped that a ship can also be "frozen in" as a semipermanent laboratory.

A concerted effort will be made to improve geophysical techniques. New methods of sub-bottom exploration will be examined. Magnetic and gravity instruments will be improved by making them more sensitive and more reliable. An attempt will be made to integrate the output of many of these sensors on punched or magnetic tape for digital use along with providing the conventional analog display. Computer techniques for analyzing seismic records will be investigated.

Non-routine ideas for exploring the ocean bottom will be supported. These will include scientific investigation made by the TRIESTE and ALUMINAUT. In addition, the Navy will continue to support, along with the National Science Foundation, the program of deep ocean drilling in Project MOHOLE.

Hydrographic Office

FY-62 \$100,000

FY-63 \$130,000

The Hydrographic Office program for FY-63 includes research leading to improvements in survey equipment and techniques for application on, above and beneath the surface of the sea, and to the development of new and improved methods of data analysis programmed to the maximum possible utilization of electronic computer technology. The conversion of oceanographic information into appropriate military terms and the prediction of environmental conditions in both time and space are major research objectives. Improved capabilities for naval operations through improved knowledge of the interactions of the marine environment with naval systems will be emphasized.

In its FY-63 program the Hydrographic Office will devote considerable research effort to the description and understanding of the sea floor and associated geophysical and geological phenomena. A number of tasks will be concerned with longer range objectives leading to the scientific extrapolation of geophysical and geological conditions and the conversion and display of these predicted conditions into forecasts of military significance.

The use of data concerning sea floor and related phenomena depends to a large extent on the ability to position accurately at sea. Analysis of present navigation system capabilities, accuracies, and limitations will be undertaken along with other Naval activities, and the data obtained will be used to provide guidance for improving present capabilities and in evaluating new systems. Capabilities for rapid and

accurate topographic and physiographic descriptions of the sea floor will be developed through advances in bathymetric measuring techniques. Improvements in micro-bathymetric techniques will be attempted by towing a transducer close to the ocean bottom. This may allow for more detailed study of the floor than is at present possible. Concurrently, reflectivity measurements of the ocean floor will be taken for use in future reflectivity prediction studies. Specialized photogrammetric instruments are to be developed to allow rapid and accurate compilation of bathymetric features with the use of underwater photography.

Observations of gravity data will provide information on the sea floor and the underlying mass as manifested in density contrasts. Development, testing and evaluation of an airborne gravity measuring system will be undertaken. This system must be compatible with the types of naval aircraft and navigational systems available for collecting other geophysical data.

Analyses will be made of the frequency and lower spectrum of magnetic signals as monitored from aircraft. This project requires geomagnetic data of high quality obtained under controlled conditions. Magnetic tape recordings of geomagnetic information will be used during analysis of procedures.

Bureau of Ships

FY-62 \$575,000

FY-63 \$802,000

Within the Bureau, geological-geophysical research will be supported at the Navy Electronics Laboratory and the Lamont Geological Observatory. Both programs contain elements of basic research although emphasis is on problems of sound propagation. Sea floor studies at NEL will consist of sound transmission characteristics in sediments, identifiable properties correlated with acoustic properties, sediment types and formation affecting mine hunting and mine burial, shear strength of sediments, theory of deep water sediments (lithification, etc.), deep photographic studies of ripples, sediment transport and canyon flushing. The TRIESTE will be used in connection with these studies wherever its unique operational characteristics permit. Acoustic investigation of the sub-bottom will be pursued using sonoprobe techniques. Likewise, the program at Lamont is directed toward understanding the characteristics of ocean sediments and the earth's crust beneath them as they affect sound transmission. This will include detailed bathymetric work, analysis of core samples, seismic studies and the development of special instruments for use in marine geophysics.

Establishment of an acoustic data center, where the mass of unassessed and uncorrelated information from various laboratories can be drawn together, evaluated and placed in a fast data-retrieval system, is being considered at the Underwater Sound Laboratory.

DEPARTMENT OF THE ARMY

Office of the Chief of Engineers

FY-62 \$ 63,000

FY-63 \$100,000

Topographic changes in coastal waters will be studied with relation to navigation channels, the silting of jetties and breakwaters and the control of shoaling. These changes represent a complex interaction of tidal currents, wave action and littoral drift. The projects involve field studies, laboratory tests, and data analyses. Use will be made of research institutions as well as government laboratories in this work.

The meeting of tidal currents and storm waves at inlet bars represents probably the most violent aspect of oceanography, and the study of this action is costly and difficult. A research study is underway to improve the ability to analyze these actions in small-scale laboratory wave and tidal basins.

The mechanics of tsunamis (earthquake generated waves) will be studied with particular reference to the increase in height in shallow water and the run-up of these waves on the shore.

Startling changes in the oceanic environment have occurred in the coastal zone where the tidal bays, lagoons and estuaries are subjected to shoaling processes from silting and to erosion by internal waves and tidal currents. Here, the interplay has resulted in the silting up, within historic times, of large bays (e.g. - the Louisiana marshes) and, conversely, the erosion of great areas by wave attack (e.g. - banks of Chesapeake Bay). Studies of the shoaling and the erosion in these tidal waters will be carried out as part of this research program.

Beach Erosion Board

FY-62 \$149,000

FY-63 \$152,000

Every wind movement over the ocean generates a wave train. The accumulated energy in these wave trains is constantly being dissipated on the shores and beaches of the land masses. The Board's research program contains a series of studies to determine the relationship between the character of the waves and the changes (erosion or accretion) of the shore. Studies will continue to be made to determine seasonal beach changes from wave action, as well as more abrupt changes, from a single violent storm.

The formation and disappearance of offshore bars and beach cusps, berm creation and destruction, equilibrium profiles, and the rate of littoral transport of sand along the shore are other projects that will be continued or begun in FY-63. Studies on basic mechanisms of transport by waves and currents will be continued, through both university contract and laboratory work. The amount of sand in suspension under wave action is under study, as is the proportionate relation of this suspended material to littoral transport rate. Use of various fluorescent

and radioactive tracer materials in beach studies is contemplated in field studies in FY-63. Better description of shore and nearshore materials are being sought, particularly through statistical means utilizing computers, and studies are underway on the sorting and redistribution of materials under wave action.

DEPARTMENT OF COMMERCE

Weather Bureau

FY-62 \$ 0

FY-63 \$ 0

The Weather Bureau's interest in the sea floor topography and its relation to surrounding land masses is restricted to the deflection, blocking, or channeling of major ocean currents and the resulting climatic effects. The potential of areal weather and climatic modification could conceivably include the physical change in the flow pattern of ocean currents.

The Weather Bureau is interested in studies relating current, topography and climatic change, but does not plan to fund for such research in FY-63.

Coast & Geodetic Survey

FY-62 \$206,000

FY-63 \$301,000

The hydrographic surveys and marine geophysical (magnetic and gravity) operations of the Coast Survey contribute directly to this research Objective. Although most of the funds for these operations are listed under "surveys", there is no sharp dividing line between surveys and research. Recent research projects have been reported in professional publications and include the geological interpretation of bathymetry along the continental slope off southwest Florida and a similar study of the Florida Straits south of the Keys. Other research projects include the geology of a newly-discovered bank rising from deep water in the Caribbean, a study of migrating sand waves on Georges Bank, a study of the area of bottom erosion and sedimentation in Chesapeake Bay, the geology of the sea floor in the Gulf of Alaska, changes in Lituya Bay, Alaska, resulting from recent earthquakes, and a study of the rising land mass in southeast Alaska. Investigations of this nature will be considerably expanded in FY-1963.

Working with the Geological Survey, geophysicists of the Coast Survey are studying the distribution of magnetic anomalies in the Arctic. Marine Geophysical work is currently being carried out in the Chukchi Sea, in the North Pacific and off the northeast Atlantic Coast. Acquisition of additional magnetometers and another shipboard gravity meter planned for FY-1963 will increase the capabilities of the Coast Survey in this field.

Equipment has been purchased which will provide information on the thickness of recent sediments and structure of the subsurface layers. A new deep-sea camera to be used jointly by Coast Survey photogrammetrists and oceanographers will be used for research on the sea floor.

Rock samples from the Florida Straits and the West Florida Shelf, and sediment cores from the North Pacific, collected from Coast Survey ships, have been analyzed by the U. S. Geological Survey on a cooperative basis, and marine geophysicists from that agency and from the Scripps Institution of Oceanography have and will continue to work with the Coast Survey on cooperative research projects.

During FY-1962, the extensive ocean-wide survey operations in the North Pacific provided, for the first time, accurately controlled data from which the Coast Survey is constructing charts which will show for the same area the total magnetic field, the gravity anomalies, and the bottom topography. These are valuable research tools for studies of the geologic history of the ocean basin.

During FY-1962, the Coast Survey made its first research grant for marine geological research. This was to a graduate student at Johns Hopkins working on the problem of underwater sand ridges. This grant will probably continue in FY-1963, and it is planned that others will be made when the funds become available.

DEPARTMENT OF THE INTERIOR

<u>Bureau of Commercial Fisheries</u>	FY-62 \$11,000
	FY-63 \$ 9,000

The Bureau's program does not contribute significantly to this Objective, although an increasing awareness of the relation of fisheries to topographic features is being followed closely. In cooperation with Scripps Institution of Oceanography, a series of topographic charts showing locations of sea mounts in the eastern Pacific is being produced. These are for use primarily by tuna fishermen, as past research has shown that tuna concentrate near sea mounts.

<u>Geological Survey</u>	FY-62 \$205,000
	FY-63 \$230,000

The Geological Survey program contributing to knowledge of the sea floor and marine sedimentary processes can best be illustrated by the following tabulation of long-range programs to begin or to be extended in FY-63.

- 1) Structure, geologic evolution, and sedimentation of the Pacific continental margin, Western United States.
- 2) Geologic history, substructure, and sedimentary regime of the Alaskan epicontinental seas and the Aleutian Island arc.
- 3) Petrogenic provinces and boundary structures of the Pacific Basin.

- 4) Quaternary history and structure of New England continental shelf.
- 5) Substructure of the Atlantic continental shelf.
- 6) Sedimentary and diagenetic processes and provinces of the Floridian shelf seas and adjacent water areas.
- 7) Syntheses of existing knowledge of world continental shelves.
- 8) Ecology and biogeography of living and extinct marine faunas important in interpreting the geologic record.

Most of these programs have the threefold objective of: (1) determining the geologic history, subsurface structure, petrography, and evolution of the sea floor (mainly continental shelves and borderlands), (2) identifying the sedimentary, geochemical, diagenetic, structural and geologically important biological processes operating at, above, and below the sea floor, and (3) delineating and evaluating mineral and mineral fuel occurrences.

The following investigation will be carried out relative to the above:

- 1) Analytical laboratories.

Studies of diagenetic processes with special reference to glauconite, zeolites and clays.

Spectrochemical analysis of aquatic sediments and related waters.

- 2) Isotope geology.

Continuous gamma radiation profiles of bottom sediments.

Investigation of physical properties with in situ measuring and sampling devices.

Marine geochronological and paleotemperature research.

- 3) Geochemical exploration and minor elements.

Studies of materials and minor elements in marine sediments.

Preparation of standards for, construction and operation of compact mobile laboratories for shipboard and shoreside use.

Special research on minor element distribution in the aquatic realm.

4) Experimental geochemistry and mineralogy.

Studies of mineralogy of marine sediments.

Marine geochemical research.

5) Paleontology and stratigraphy.

Marine geochronological and ecological research.

6) Theoretical geophysics.

Measurements and instrumentation for special physical properties in connection with Project MOHOLE.

Research with marine surface gravimeter and magnetometer.

Extension of seismic investigations to the sea off southern California.

The aim of the FY-63 program is to develop new concepts and improved techniques that will be useful in (1) understanding and describing the distribution and variations in abundance of the elements and their compounds in space and time, (2) determining the composition, structure and history of the earth, and (3) delineating and evaluating mineral deposits, fuel deposits and water resources.

Bureau of Mines

FY-62 \$ 0

FY-63 \$ 0

The investigation of the Bureau of Mines that leads toward this Objective is described under Objective Five.

DEPARTMENT OF THE TREASURY

Coast Guard

FY-62 \$ 0

FY-63 \$ 0

Coast Guard activity in Objective Four is limited to bathymetric sounding tracks in conjunction with other Coast Guard functions. This is in cooperation with the U. S. Navy Hydrographic Office. In FY-63 it is estimated that 365,000 miles of echo sounding tracks will be compiled. This activity is not funded with research money.

NATIONAL SCIENCE FOUNDATION

FY-62 \$1,550,000

FY-63 \$2,130,000

The geological, geochemical and geophysical oceanographic investigations supported by the Earth Sciences Program of the National Science Foundation are directed toward obtaining a basic understanding of the sea floor and its structure. Among others, research in these areas is supported at the Universities of Miami, California, Washington, Michigan, Southern California, Missouri, and Georgia, as well as Florida State, Columbia, Yale, and Rice University.

The geological and geochemical research covers a wide range of problems requiring both laboratory and field efforts. Some of the general topics receiving support are:

- (a) the stratigraphy of deep-sea cores in the Atlantic Ocean, Pacific Ocean, Indian Ocean, and the Caribbean Sea;
- (b) X-ray diffraction and spectrographic studies of oceanic and coastal marine sediments;
- (c) micropaleontological studies of Atlantic and Pacific Ocean cores;
- (d) paleotemperatures as determined by the oxygen 16-18 ratios of the calcium carbonate fractions of deep-sea sediments;
- (e) rates of sedimentation principally by Carbon-14 analysis;
- (f) the dynamics of sediment transportation;
- (g) the geochemistry of radioactive and stable isotopes;
- (h) the exchange phenomenon between the sediments and the sea;
- (i) sediment petrology and the development of minerals; and
- (j) lithofacie and biofacie surveys of marine sediments.

The principal aim of geophysical investigations at sea is to advance our knowledge of the surface and subsurface of the sea floor. Bathymetric,

seismic, gravity, magnetic and thermal investigations receive both direct support and indirect support in the form of ship construction, modification and operation. During the numerous cruises and expeditions sponsored by the National Science Foundation, many geophysical measurements are taken. An example of this is the geophysics program supported by the Foundation and conducted by Scripps, Lamont and Woods Hole.

OBJECTIVE FIVE - TO DETERMINE HOW THE OCEANS CAN BE EXPLOITED TO BENEFIT MANKIND

All oceanographic investigations are pointed toward the ultimate goal of maximum utilization of the world ocean for the betterment of mankind. Much of the present and planned research is immediately pertinent to this goal. In most cases, however, we cannot immediately evaluate the ultimate use of basic oceanographic research. However, all the hopes for ultimate utilization of the oceans are dependent upon basic research. For example, if we hope eventually to be able to modify and control the weather the physical oceanographers and meteorologists must have a better understanding of the processes now in operation at the air-sea interface. Such control is pure speculation without this understanding. The same holds true for increasing our food supply from the sea, and obtaining more minerals. We must understand what is going on in the sea before we can exploit it. Once we have the facts - and only then - will we have the potential to understand the ocean to utilize its fullest potential.

DEPARTMENT OF DEFENSE

DEPARTMENT OF THE ARMY

<u>Office of the Chief of Engineers</u>	FY-62 \$21,000
	FY-63 \$20,000

Flood control works of man frequently divert large quantities of fresh water from one estuary to another. These diversions may produce great changes in the bays and estuaries affected by the change. For instance, the diversion of Mississippi flow into the Atchafalaya has resulted in significant changes in the Atchafalaya delta. Resulting salinity and silting conditions have affected both the fish life and the hydrography. Such changes can be made to be beneficial rather than harmful to mankind.

As part of its research program the Corps is evaluating the factors controlling salinity, mixing, flushing and silting of estuaries. The goal is to obtain a quantitative evaluation of these factors enabling the effects of river diversion of the oceanic environment to be calculated beforehand so that harmful effects can be anticipated and avoided. The program of research is rather broad and will include studies of salinity, currents, flocculations, and the erosion and transportation of bottom materials both in the laboratory and field. Research will also include studies of the effects of enlarging the entrance channels to inlets and estuaries.

DEPARTMENT OF COMMERCE

<u>Weather Bureau</u>	FY-62 \$ 0
	FY-63 \$ 0

Most of the Weather Bureau's program, described under Objective Two, also contributes to Objective Five. If weather is to be controlled

to the benefit of man, we must understand more thoroughly air-sea interactions.

Coast & Geodetic Survey

FY-62 \$ 0

FY-63 \$ 0

All of the Coast & Geodetic Survey's programs such as: research on tsunamis to improve the prediction techniques for the warning system, current studies and charting activities for navigation, tidal studies for use by coastal engineers and for storm surge studies are germane to Objective Five. However, they have been described and budgeted in either the other objectives of this report or within the Survey Program.

DEPARTMENT OF INTERIOR

Bureau of Commercial Fisheries

FY-62 \$825,000

FY-63 \$914,000

One of the principal ways in which man may modify the oceans is through inducing a biological imbalance by the continued harvesting of certain desirable species and the neglect of species of no commercial value. Such selection imposes an additional mortality on species sought by fishermen over that which occurs naturally, and it raises two questions: (1) what effect does fishing have on relations between species and (2) what rate of exploitation can be applied to a population to obtain the maximum sustainable yield? The Bureau directs considerable research towards the first question in present programs and will continue to do so in the future. No new programs are planned specifically on rates of exploitation in 1963.

Experiments to induce mass biological productivity, such as creation of artificial upwelling or fertilization of the sea with trace elements which may be critical to high abundance of basic producers, have been proposed. It would appear that such experiments can, in time, be successful but that their chances of success will be greatly enhanced after the relations between productivity and physical and biologic processes are better known. Biologists do not know how most marine animals respond to their present environment except in a very crude way for some species. Therefore, this information should be gained before giving high priority to experiments which would have to be conducted on a trial basis because of lack of present information to design them properly.

Improvements in ways to catch fish are being sought. For example, experiments will be made to herd fish, with curtains made from air bubbles, into electrical fields from which they will be pumped aboard ship.

Research on coastal and inshore oceanographic conditions in the Gulf of Mexico is to be expanded. The aim for this work is to learn the extent that engineering and industrial developments are altering the

natural biological, physical and chemical regimes and consequently the productivity of Gulf coastal and estuarine areas. The effects which dredging, channelization, land reclamation and other modifications have on circulation, sedimentation and salinity will be studied.

Geological Survey

FY-62 \$15,000

FY-63 \$63,000

One of the primary responsibilities of the Geological Survey is to locate, delineate and evaluate potentially useful deposits of minerals and mineral fuels on and beneath the continental shelves, slopes and borderlands, the deep sea floor and in the waters of the sea itself. A substantial increase in effort to carry out this responsibility will be made during FY-63.

Bureau of Mines

FY-62 \$50,000

FY-63 \$50,000

One of the principal missions of the Bureau of Mines is the conservation and development of mineral resources. To discharge this responsibility, the Bureau of Mines investigates occurrences of minerals and conducts research on mining and means of extracting metals from their ores or otherwise preparing minerals for market. Its activities have been confined largely to minerals and fuel deposits on land. Many such deposits were laid down beneath prehistoric seas and the knowledge gained from their study can be extrapolated readily to present-day ocean bottom deposits. The need to broaden the Nation's mineral resources base makes it both logical and imperative to extend Bureau of Mines investigations to encompass the mineral deposits that lie beneath the ocean and to the elements that are dissolved in the ocean itself.

The Bureau of Mines has begun a limited program of analyzing ocean bottom samples, taken by other oceanographic research organizations, to determine the occurrence of valuable elements and minerals in the sediments on the sea floor. Available data on such occurrence is being collected and evaluated as a basis for future programs.

Theories and techniques of sampling the huge sea areas of the sea floor will be studied. Research will be undertaken on means of selective separation of trace elements from the very dilute solution that is sea water.

OBJECTIVE SIX - TO DETERMINE THE EFFECT OF RADIOACTIVITY AND POLLUTION ON THE PHYSICAL, CHEMICAL, GEOLOGICAL AND BIOLOGICAL PROPERTIES OF THE OCEANS

Although research in this category may overlap with any or all of the preceding objectives, the implications of contamination of the ocean seem to justify a separate examination of this aspect of the oceanographic program. Studies of radioactivity and other pollution are supported by the Atomic Energy Commission (AEC), the Department of Health, Education and Welfare (HEW), and the U. S. Bureau of Commercial Fisheries (BCF). The AEC has the principal research program concerning radioactivity in the ocean; the HEW is principally involved in actual and potential health problems in the ocean; and the BCF is concerned with the effects of pollution on fishery resources now and in the future. In addition, the Bureau of Sports Fisheries and Wildlife, Navy, the Coast Guard, the Coast and Geodetic Survey, the Bureau of Mines, the Army Engineers and other agencies must be prepared to consider their operations from the standpoint of pollution and under given circumstances any of these agencies may develop an operational program in pollution research. For example, the Navy has carried out pollution research in connection with its weapons development program and the Bureau of Sports Fisheries and Wildlife is developing a capability for investigating pollution as an aspect of its responsibility for marine fishery resources.

DEPARTMENT OF DEFENSE

DEPARTMENT OF THE NAVY

<u>U. S. Navy Hydrographic Office</u>	FY-62 \$20,000
	FY-63 \$20,000

A critical area for additional effort will be field and theoretical studies of flushing and dispersion of contaminants which go into solution. Dye dispersal techniques and turbulence measurements will be valuable. Studies on motion of contaminated water will be carried out in nearshore, estuarine and deep oceanic waters.

DEPARTMENT OF THE ARMY

<u>Office of the Chief of Engineers</u>	FY-62 \$21,000
	FY-63 \$20,000

Hurricane protection measures often involve the construction of permanent seawalls or dikes across inlets to shut out the hurricane surge. These walls or dikes may alter mixing and flushing characteristics of the tidal flow and affect the pollution and the fish life of the area. The FY-63 research program will include studies to evaluate the effects of full or partial barriers to tidal flow.

DEPARTMENT OF COMMERCE

Coast & Geodetic Survey

FY-62 \$ 0

FY-63 \$ 0

To date, the contribution of the Coast and Geodetic Survey to this research objective has been only as a reimbursable collector of data. Under contract to the Atomic Energy Commission, the C&GS has carried out several environmental studies off the Atlantic Coast; studies involving currents, bottom topography, sediments and bottom-dwelling organisms. In the past the Coast Survey, at the request of the Atomic Energy Commission and the Maritime Administration, carried out an extensive study of the currents, temperature, and salinity of New York Harbor to provide the basic information for estimating the flushing time of radioactive contamination from the Harbor. Special sediment collections have been made for the Public Health Service for use in their radioactivity surveillance program.

During FY-1962, the PIONEER had aboard a radiochemist from the Scripps Institution of Oceanography who was carrying out sampling and concentration operations as part of a study of the distribution of Cesium-137 in the North Pacific. Cooperative endeavors of this type will continue in FY-1963.

In FY-63 the C&GS obtained one small vessel specifically for shallow water and estuarine circulatory surveys. In FY-63 this ship will be used in Charleston Harbor in an extensive study of the current regime, and the resulting studies will provide information of use in this research objective.

DEPARTMENT OF INTERIOR

Bureau of Commercial Fisheries

FY-62 \$100,000

FY-63 \$151,000

Radioactivity - The Bureau of Commercial Fisheries has conducted research in cooperation with the Atomic Energy Commission for more than 10 years at the Beaufort, North Carolina laboratory. This research is providing information on the accumulation of radioactivity by marine species and the effect of this accumulation upon the well-being of the species. This is a continuing program providing basic information which can be used to evaluate the hazards of various levels of radioactivity upon food fish products. It is expected that research, which until now has been in the laboratory, will be expanded to consider results in small enclosed pools or tanks.

In 1961, the Bureau began a cooperative study with Public Health Service on the distribution of radioactive substances in the estuary of the Savannah River in Georgia. The Bureau's part of this project has been to supply a marine biologist to assist in planning and carrying out field sampling to develop satisfactory procedures for monitoring levels of radioactivity in streams. Funds for this project were supplied by the Division of Radiological Health of the Public Health Service.

The Bureau also began a radiobiology consultation program in 1961 to evaluate the effect of proposed nuclear plants upon fish and shellfish. This project, which is based in Washington, D. C., will be expanded in FY-63 since at least two more specialists will be required to meet the increased workload caused by the increase in the number of applications for Federal licenses to construct nuclear plants.

The Bureau also plans to construct a new radiobiology laboratory at Beaufort, North Carolina during 1963. This will replace an existing laboratory which has been frequently flooded by hurricanes.

Pesticides - Under special authorization by Congress, both Bureaus in the Fish and Wildlife Service are conducting research on the effects of pesticides on fish and wildlife. Research is being carried on at Milford, Connecticut, where the effects of pesticides on oyster and clam larvae are being studied. In Alaska the Bureau is cooperating with the Forest Service in evaluating the effect of forest spraying on the eggs and fry of salmon. The major portion of the Bureau's research on pesticides is conducted at the Gulf Breeze, Florida laboratory, and at present concerns the effects of pesticides on juvenile and adult fish and shellfish.

In 1963, field studies on the effect of pesticides will begin in the estuaries of the Gulf of Mexico. This project will probably continue for a number of years since many pesticide chemicals have not yet been studied, and since more information is required before the Bureau can advise pest control agencies of safe tolerance limits for aquatic species.

Estuarine Studies - In the broad sense, studies of the bays and estuaries along the Gulf Coast are concerned with effects of changes in the environment which might be described as pollution. These studies, which are based at Bureau laboratories at Galveston, Texas and St. Petersburg Beach, Florida, are concerned with the hydrology of inshore waters and the tolerance of estuarine species to changes in their environment. Information gathered in these studies will provide a basis for predicting the effect of proposed engineering changes in coastlines, waterways, marshes and bays upon commercial fishery species. Among the possible changes in environment are increased turbidity, changes in salinity and temperature, reduced fishing rates, and decreased river flows which might reduce the dilution of domestic wastes. These studies began in 1961 and were continued in 1962. It is planned that funds for estuarine studies will be increased for FY-63.

Bureau of Sport Fisheries & Wildlife

FY-62 \$ 54,000

FY-63 \$100,000

Pesticides - The Bureau operates a Fish-Pesticide Research Laboratory to study the effects of insecticides and other pesticides on fishery resources. Studies involve the identification and measurement by

chemical analysis and bioassay of pesticide chemicals in fishes, and the plants and animals on which they depend; definition of the immediate and cumulative effects of the chemicals; and the determination of the toxic and lethal levels of both dissolved and ingested pesticides. Standards for pesticide content of the environment which can be endured without severe chronic effects are one objective of these studies. Tolerance limits of various organisms are another.

Oil Pollution - Research is needed on the effects of oil on sport fish species, their foods, and upon waterfowl. The Bureau assists in determining areas of pollution and in the formulation of regulations covering dumping of oils in prohibited zones.

Estuarine Studies - The Sandy Hook Marine Laboratory (New Jersey) commenced a study in FY-62 of the Shrewsbury River estuary. Plans are to expand this study to include areas on both the Atlantic and Pacific Coasts, and to include documentation of environmental conditions affecting young game fish and their foods.

Experimental Biology - A prerequisite to determination of the effects of pollutants is an understanding of the survival, growth and well-being of marine organisms in relation to their environment. In FY-62, an experimental laboratory program was commenced at the Bureau's Sandy Hook Laboratory to study the influence of various environmental factors including microorganisms, under controlled conditions, on growth and physiology of marine fishes. This involves the establishment of a number of plankton cultures, a determination of their nutritional and physiological requirements, an evaluation of biochemical inter-relationships among plankton species, and test feeding of larval and juvenile fishes with various cultures of plankton tagged with radio-isotopes. This program will be continued in FY-63.

Geological Survey

FY-62 \$15,000

FY-63 \$20,000

Modifications of the oceans resulting from the activities of man are also the subject of Geological Survey research now in progress and planned for FY-63. Such research includes the effects and fate of radio nuclides and other pollutants delivered to the oceans by runoff from the land; the possible results of the use of nuclear energy for coastline modification (Project CHARIOT); the effects of man-made structures on coastal erosion; and the effect on ground-water salinity of high-water withdrawal rates in coastal areas.

DEPARTMENT OF HEALTH, EDUCATION & WELFARE

Public Health Service

FY-62 \$1,150,000

FY-63 \$1,500,000

Fundamental to the safe disposal of wastes in the marine environment is the full understanding of the effects of such wastes on marine

organisms; also any interactions between waste materials and the physical and chemical properties of sea water. This includes toxic effects on the marine organisms; concentration of toxic chemicals and pathogenic organisms in the food chain of edible marine food resources; the mechanisms causing paralytic shellfish poisoning and poisonous fish; understanding of the biology of marine organisms which may lead to their control in assimilating polluttional materials; the survival rate of pathogenic organisms in the marine situation; generic studies of marine organisms which may lead to new knowledge of human life and health; and studies to determine any medically or pharmacologically important substances which may be produced by marine organisms.

Research studies include the effect of sewage on fertilization and the effect of certain industrial wastes on the productivity of the euphotic zone; oxygen and carbon dioxide relationships with photosynthesis, respiration and growth of marine algae, bacteria and other organisms; and the relationship and effects of radiation and wind movements on biological growth and distribution. Where possible the basic findings of other agencies doing research on radiation and air-sea interface phenomena will be utilized or studied cooperatively.

During FY-63 the Public Health Service hopes to have completed two new research laboratories, one in New England and one on the Gulf Coast, in support of an expanded National Shellfish Sanitation Program. It also hopes to have in the planning stage a field laboratory and research center for pollution control, including studies of pollution of estuarine and inshore waters. The planned direct oceanographic research program for FY-1963 relating to pollution is as follows:

1. Chemical and bioassay studies of industrial wastes to determine their fate and toxicity in the marine environment; particularly as these affect shellfish, fin fish, and other aquatic life. Studies of the mechanisms and rates of biochemical reactions in sea water in relation to assimilation of sewage and industrial wastes.
2. Determination of the longevity and fate in sea water of bacteria and viruses of human origin, with special reference to contamination of recreational beaches and harbors, and saline waters that may be converted to fresh water.
3. Studies to determine the adverse effects of municipal and industrial wastes on shellfish, and of natural environmental factors which make dangerous their ingestion by man or interfere with their reproduction and growth.
4. Research to develop and perfect instrumentation and procedures for routinely detecting and measuring pollution by radioactive wastes in the inshore and estuarine waters,

including evaluation of the influence of such wastes on fishery resources and relationship to the health of consuming populations.

5. Field studies to determine dispersal patterns and velocity of water movements in inshore waters, horizontal and vertical velocities in estuarine and inshore tidal movements, and sedimentation rates under various conditions of water movement and marine topography.

The Public Health Service hopes to implement its authority to establish fellowships and make training grants at the graduate level, including support in the oceanographic sciences. It will continue to make grants for research in oceanography and oceanographic-related projects. Consultative services will be provided to state agencies and other federal agencies. Comprehensive programs for water pollution control for the Columbia River Basin, the Chesapeake Bay and Susquehanna River Basins, the Lower Delaware River and Raritan Bay Basins, and the Tri-State Metropolitan and Hudson River Basins (New Jersey, New York and Connecticut) will include the necessary research and studies for the estuarine and harbor areas, including the fate of radioactive materials in the Columbia River estuary.

In cooperation with other state and Federal agencies, the Public Health Service conducts radiological environmental surveys in estuaries.

In some instances these surveys were originated to obtain information about the background radiation levels in an estuary prior to the start of nuclear operations. In other cases, surveys were initiated to assure that the nuclear operations do not cause high activity in the marine food supply, and in still other cases they were designed to obtain basic information as to the route of radio nuclides from marine disposal to the food chain. In these investigations attention is focused towards finding indicator organisms and correlating the concentrations of radioactive substances in these organisms to the radioactive discharge from the source.

All estuary environmental survey projects are conducted on a basis that allows direct comparison of data and data examination. The samples taken and the division of samples have been detailed so as to be compatible with other estuarial areas and will allow for more precise and detailed data reporting and comparison than previously were possible. The samples are divided into significant component parts and the data are reported in a form that is adaptable to computer punched card manipulations.

The purpose of all sampling is:

1. To determine the radiation levels of seafood with due regard to nuclear weapons testing fallout, nuclear operations and other sources;

2. To select appropriate indicator organisms to be used in surveys for radio nuclides in marine environments;
3. To learn of the possible effects on the fishing industry;
4. To obtain basic data useful in determining the fate of radio nuclides in the water medium and also in the development of mechanisms for the removal of such nuclides from the aquatic environment.

Comprehensive program development projects are underway for the Columbia River Basin and the Chesapeake Bay and Susquehanna River Basins. These studies will include the water quality requirements and pollution control measures needed for the maximum utilization of the estuarine, harbor and inshore waters associated with the Columbia River Basin and Chesapeake Bay. All pollutants and their effects will be determined, including chemical toxicants and radioactive materials.

ATOMIC ENERGY COMMISSION

FY-62 \$3,840,000

FY-63 \$5,335,000

Radioactive materials have been added to the ocean from a variety of sources, including fallout from nuclear tests, packaged waste disposal, the operation of river and shore based reactors and the operation of ocean-going vessels. Since the magnitude of added radioactivity from some of these sources, as well as from exploitation of additional applications of nuclear energy in the ocean, is increasing, it is necessary to determine the actual and potential impact of such introduction of radioactivity on man and his marine resources. An understanding of general principles must be developed as well as an explanation of the processes resulting from addition of radiation and radioactive isotopes.

The marine sciences research in the AEC is aimed at the determination of the impact of radioactivity on the oceans and their contained life. Such research may be in reasonably close support of developments in nuclear devices and their operational testing. However, the research problems generally have applications that extend well beyond the specific experiment.

Research into the abundance, periodicities and fluctuations, as well as of the economic importance of marine organisms, are made of areas adjacent to or potentially affected by such operations and sites for disposal of wastes from nuclear industries. Studies include inter-relationships of organisms in food webs, reproductive cycles, migratory habits, aggregation, etc. in order to evaluate properly the many ways that radioactivity may be concentrated and dispersed in the marine environment.

Different organisms have been demonstrated to be especially effective in concentrating isotopes of cobalt, iron, manganese, phosphorus, strontium, zinc, ruthenium, yttrium, cerium, etc. The AEC is seeking to learn whether the concentration is repeated at various trophic levels and whether such concentrating ability results in hazard to man as well as whether or not the concentrating power can be used to advantage in decontaminating radioactive areas in the ocean. Since at least twenty to thirty important isotopes may occur in thousands of significant marine species in variously acceptable chemical states, it would appear that studies must be continued for a long time before the role of radioactivity in the marine environment is determined with reasonable assurance.

Radioactive materials may go into true solution, they may occur in a colloidal state or they may be particulate in the ocean. Sediment transport and sedimentation phenomena must be studied to permit predictions concerning distribution of oceanic radioactivity. Studies are necessary of the modes of transfer of radioelements from sea water to sediments and from sediments to sea water in order to understand their reactions and to trace geochemical processes that affect their distribution.

Naturally radioactive elements and cosmic ray produced isotopes are apparently at equilibrium in the ocean with geological time. The movements and effects of introduced radioactivity may be with similar naturally occurring radioactive isotopes; thus, studies of the naturally radioactive materials are necessary. Since the rates of decay are constant of uranium and thorium as well as their radioactive daughter elements, the absolute quantities of such isotopes can be related to produce an approximate age of sediments and to trace geochemical processes of importance in the materials budget of the earth.

Biological processes modify theoretical distribution of sediments. Studies of biological processes will give considerable data concerning the relative effectiveness of chemical and biochemical processes in the removal of radioactivity from the ocean water. Investigations of the removal of radioactivity by feeding marine organisms and the binding of such material in their waste products will continue.

In attempting to explain the actual and potential distribution of radioactive isotopes in the ocean, circulation and mixing processes are studied in various ways.

Radioactive isotopes from fallout are useful in providing knowledge of the vertical and horizontal mixing of ocean waters. Some isotopes apparently move with horizontal currents and others may show laminar flow along thermal layers. Abundance with depth of radioactive isotopes which were added in a reasonably uniform manner to surface

waters gives information concerning the ocean that is otherwise difficult to obtain.

Recent developments in techniques for study of fluorescent dyes indicate that diffusion studies of materials at depths in the ocean will soon be feasible. Along with carefully controlled introduction of nuclear materials, diffusion tests will help to explain oceanic phenomena as well as improve the prediction of effects of accidental or deliberate loss of nuclear devices into the ocean.

Studies of circulation and mixing processes in coastal waters and estuaries provide information of value to nuclear operations in these waters, and they may add substantive information to our understanding of such processes as upwelling and fishery production.

BUDGET for Fiscal Year 1962 and 1963
(Thousands of Dollars)

FY	Agency	OBJECTIVES						TOTAL
		1	2	3	4	5	6	
DEPARTMENT OF DEFENSE								
Navy								
62	Office of Naval Research	\$ 5,234	\$ 1,291	\$ 1,232	\$ 6,160	—	—	\$13,917
63		6,397	1,365	1,803	7,380	—	—	16,945
62	Hydrographic Office	\$ 80	\$ 100	—	\$ 100	—	\$ 20	\$ 300
63		80	299	—	130	—	20	529
62	Bureau of Ships	\$ 334	\$ 400	\$ 166	\$ 575	—	—	\$ 1,475
63		570	715	198	802	—	—	\$ 2,285
Army								
62	Chief of Engineers	\$ 30	\$ 100	—	\$ 63	\$ 21	\$ 21	\$ 235
63		50	150	\$ 10	100	20	20	350
62	Beach Erosion Board	\$ 32	\$ 79	\$ 3	\$ 149	—	—	\$ 253
63		134	81	10	152	—	—	377
DEPARTMENT OF COMMERCE								
Weather Bureau								
62		—	\$ 123	—	—	—	—	\$ 123
63		—	173	—	—	—	—	173
62	Coast & Geodetic Survey	\$ 200	—	—	\$ 206	—	—	\$ 406
63		300	—	—	301	—	—	601
62	Maritime Administration	—	\$ 50	—	—	—	—	\$ 50
63		—	50	—	—	—	—	50

BUDGET (cont.)

FY	Agency	1	2	3	4	5	6	TOTAL
DEPARTMENT OF INTERIOR								
62	<u>Bureau of Commercial Fisheries</u>	\$ 850	\$ 25	\$ 5,598	\$ 11	\$ 825	\$ 100	\$ 7,409
63		1,219	36	6,136	9	914	151	8,465
62	<u>Bureau of Sport Fisheries</u>			\$ 100			\$ 54	\$ 154
63				147			100	247
62	<u>U. S. Geological Survey</u>	\$ 106	\$ 10	\$ 74	\$ 205	\$ 15	\$ 15	\$ 425
63		123	34	80	230	63	20	550
62	<u>Bureau of Mines</u>					\$ 50		\$ 50
63						50		50
DEPARTMENT OF HEALTH, EDUCATION & WELFARE								
62	<u>Public Health Service</u>						\$ 1,150	\$ 1,150
63							1,500	1,500
62	<u>Office of Education</u>	\$ 50		\$ 59				\$ 109
63		50		59				109
DEPARTMENT OF TREASURY								
62	<u>Coast Guard</u>							
63								
62	<u>NATIONAL SCIENCE FOUNDATION</u>	\$ 2,150	\$ 750	\$ 2,600	\$ 1,550			\$ 7,050
63		2,450	1,200	3,100	2,130			8,880
62	<u>ATOMIC ENERGY COMMISSION</u>						\$ 3,840	\$ 3,840
63							5,335	5,335
62	<u>SMITHSONIAN</u>							
63				\$ 250				\$ 250
62 TOTALS	\$ 9,056	\$ 2,928	\$ 9,832	\$ 9,019	\$ 911	\$ 5,200	\$36,946
63		11,373	4,103	11,793	11,234	1,047	7,146	46,696



